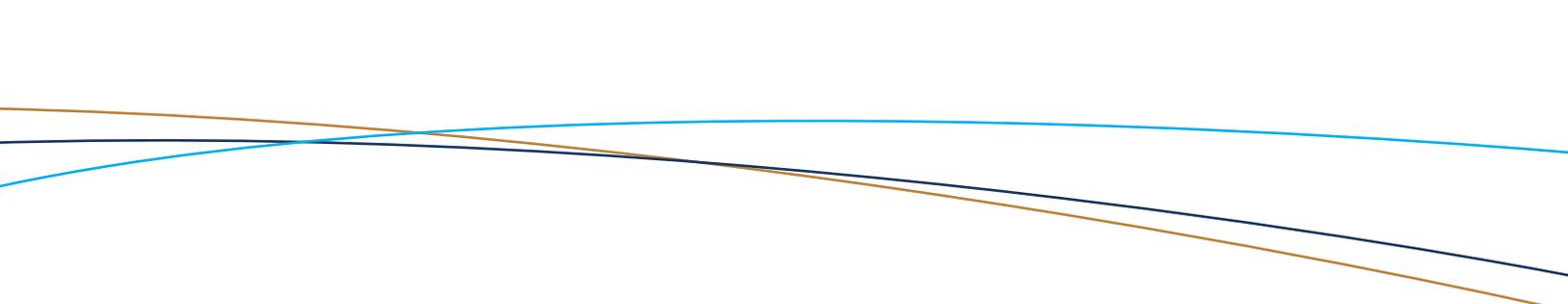




2014–2015 Technical Results Summary

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PREFACE

This report was compiled by Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA) and Environment and Climate Change Canada with input from multiple monitoring organizations.

The report presents results from the implementation of monitoring activities in year three (April 1, 2014 to March 31, 2015) of the Joint Canada/Alberta Implementation Plan for Oil Sands Monitoring under the joint leadership of AEMERA, on behalf of the Government of Alberta, and of Environment and Climate Change Canada on behalf of the Government of Canada.

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1. Introduction

The three-year Joint Canada/Alberta Implementation Plan for Oil Sands Monitoring (JOSM) represented a phased approach aimed at improving the scientific integrity, accessibility and transparency of results from the ambient environmental monitoring activities conducted by several different organizations. Implementation has produced more data for a greater range of potential environmental stressors, sampled at a higher frequency and over a broader area. The dominant characteristic of these data has been described in previous reports, namely that there is consistent, ongoing evidence of low-level changes on the ambient environment related to development activities. These changes are most pronounced in the areas in close proximity to intense oil sands development, diminishing with distance from development sites; in some cases (e.g., landscape disturbances, substances in lake sediment cores, and comparison with measurements from the 1970s and 1980s), these changes have increased over time.

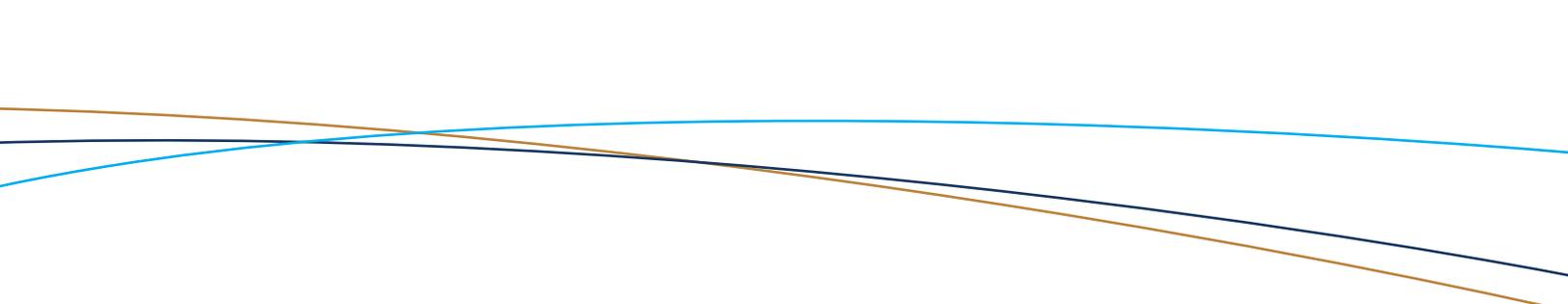
Did You Know?

While the cumulative effects of oil sands development on the ambient environment are, to date, generally low level and not cause for immediate concern, the ability to measure these effects is essential for identifying any potential long-term impacts with sufficient time for corrective actions to be effective.

While the magnitudes of the changes seen today are most often within guidelines for protection of the environment, some of the disturbances, concentrations of substances and related effects seem to be increasing. Effective ambient cumulative effects monitoring efforts will need to adapt to resolve any detectable trends or emerging signals in the data. Advance warning of significant trends or effects is needed to allow for time to implement the required focused studies of cause, and related corrective management actions. Adaptive monitoring, where the intensity of monitoring is adjusted to focus on signals of concern and/or trends in the observed data, was foreseen as an essential future objective of JOSM. With three years of data now available, there is a growing and more consistent base of information to inform, adapt and optimize future monitoring efforts according to signals in the data as well as Indigenous and stakeholder input.

Did You Know?

The known impacts of oil sands development include the disruption of quantity and/or quality of habitat for aquatic and terrestrial organisms, and the exposure to potentially harmful chemical substances in the air, water and land; many of these substances also occur naturally in the region.



Oil sands development has two major classes of environmental stressors: exposure to increased concentrations of chemical substances, and the disruption of quantity and/or quality of habitat that supports regional terrestrial and aquatic biodiversity.

Due to the specific geography and geology of the oil sands area, there are a number of chemical substances specific to the area that occur naturally and may also be introduced or concentrated by the extraction and processing of oil sands deposits. Monitoring activities specifically measure polycyclic aromatic compounds (PACs), particulate matter (PM), acidifying compounds, metals, nutrients and naphthenic acids. Monitoring measurements serve to indicate the concentrations of substances in air, water, groundwater, snow, sediments and biota at different geographic locations and over time. These measurements provide the evidence required to understand the sources, distribution and chemical reactions of these substances in the environment, and the potential exposure to these substances for living organisms. In addition, monitoring also serves to determine whether these substances are entering the terrestrial and aquatic food chain and affect plant, aquatic insects, fish and wildlife health.

The detailed data underlying the information and results in this report can be found on the [JOSM](#) and [AEMERA](#) portals.

2. Air Monitoring

Monitoring in the Wood Buffalo and Lakeland airshed zones revealed periodic exceedances of Alberta Ambient Air Quality Objectives (AAAQOs) for hydrogen sulphide, fine particulate matter (PM_{2.5}) and ozone.

In the Wood Buffalo airshed zone, both the AAAQOs for hydrogen sulphide concentration over 1-hour and 24-hour periods were exceeded occasionally at stations located near oil sands mining activities north of Fort McMurray (Lower Camp, Mannix, Mildred Lake, CNRL Horizon and Fort McKay South). The 1-hour and the 24-hour AAAQOs for the concentration of PM_{2.5} were also exceeded at all stations during certain times of the year, primarily correlated with smoke from forest fires. These data were undoubtedly augmented by direct industrial emissions at stations located close to oil sands mining operations, and by chemical reactions in the atmosphere. The 1-hour AAAQO for ozone was exceeded in 2014 at the Fort McKay South, Fort McKay Bertha Ganter and Wapasu stations.

Did You Know?

Environmental Objectives and Guidelines are science-based goals intended to protect environmental and human health by highlighting monitoring data that suggest an increased risk of specific detrimental effects. Objectives and Guidelines are meant to inform effective management actions based on specific situations and may vary nationally and provincially.

In the Lakeland airshed zone, the 1-hour AAAQO for hydrogen sulphide was exceeded once at the Maskwa station. The 24-hour AAAQO for hydrogen sulphide was exceeded twice at the Maskwa and Cold Lake stations. In addition, the 1-hour Alberta Ambient Air Quality Guidelines (AAAQG) and 24-hour AAAQO for PM_{2.5} were exceeded at the Cold Lake and St. Lina stations several times during the summer months, which were correlated with forest fire smoke.

The [Lower Athabasca Regional Plan \(LARP\)](#) utilizes triggers and limits as the two main types of indicators for assessing potential environmental risk for monitoring data. To help ensure specified environmental limits are not exceeded for a given chemical parameter, triggers provide early warning and indicate when a limit is being approached. Triggers also help the Government of Alberta, industry and others to take corrective action before a limit is reached.

Air quality limits under LARP are based on Alberta's AAAQOs developed to protect Alberta's air quality. In 2014, the LARP air quality limits were not exceeded for nitrogen dioxide (NO₂) and sulphur dioxide (SO₂). However, the Level 3 trigger for SO₂ was exceeded at two monitoring stations located close to oil sands facilities. As outlined

in the LARP Air Quality Framework, the finding of Level 3 trigger exceedance does not signal that environmental conditions have placed human health or the environment at risk. Exceeding a Level 3 trigger causes Alberta Environment and Parks (AEP) to undertake a management response.

Concentrations of NO₂ and/or SO₂ at eight monitoring stations were higher than the LARP Level 2 trigger. Level 2 trigger exceedances indicate that continued monitoring is needed to improve understanding of trends.

AAAQO guidelines are based on the concentration in air of benzo(a)pyrene, measured as the representative for PACs. Approximately 70% of the PAC concentration data at the Lower Camp site (AMS11) are below the AAAQO for benzo(a)pyrene (0.3 ng/m³); however, the annual average was above for each of the years between 2011 and 2013. Monitoring data from 2011 for the months of May and June were excluded in the AAAQO calculations because of forest fires affecting the regions.

Multiple existing inventories of pollutants emitted to the atmosphere were evaluated to identify the most suitable and most reliable information to use as inputs to models that predict ambient atmospheric concentrations, chemical reactions and deposition for the area. Studies indicate that tailings ponds are potentially more important sources of volatile organic compounds (VOCs) entering the surrounding air than was previously recognized. A method to derive total emissions estimates of specified pollutants from an entire facility or sub-component of a facility, based on measurements collected from an instrumented aircraft, was conclusively demonstrated and published. This method is accurate in calculating total fluxes and concentrations of several pollutants including VOCs, PM and aerosols, greenhouse gases.

Trends in NO₂ and SO₂ over the period from 2005 to 2014 were evaluated using satellite-based observations that cover the whole region to give integrated estimates of the concentrations vertically throughout the atmosphere. Spatial maps of NO₂ trends show an increase of 0–10% per decade. Spatial maps show SO₂ trends are flat or declining over the surface mining area. Integrated meteorological and atmospheric chemistry models showed that local weather conditions were very important in controlling the transport of emissions across the region, and in helping explain

Did You Know?

Triggers are set in advance (i.e. lower levels) of limits as early warning signals to flag unusual ambient environmental conditions, and support proactive management. Level 1 trigger means ambient air quality is well below limit, and exceedance does not result in a regulatory response. Level 2 trigger exceedances indicate continued monitoring is needed to improve understanding of trends. Level 3 trigger exceedances do not signal that environmental conditions have placed human health or the environment at risk but result in Alberta Environment and Parks undertaking a management response.

variability in ground-based measurements even when emission rates were constant. Focused studies demonstrated that emitted substances react in the atmosphere around the oil sands development area to create significant amounts of secondary PM in addition to directly emitted PM. Multiple types of high-quality, state-of-the-art air quality measurements at low concentrations were made at the Oski-otin measurement site in Fort McKay. The aim is to better monitor odoriferous events and to better attribute monitoring data to emission sources. Atmospheric PM was measured with a trailer-based differential absorption Light Detection And Ranging (LiDAR) system deployed for several months at two sites in the Fort McMurray area.

While there are no air quality guidelines for total gaseous mercury, from 2010 to 2013 concentrations at sites near Fort McKay and Fort McMurray were

comparable to those measured at other locations in the province of Alberta, and comparable to other rural sites affected by nearby sources. Measurements from August to September 2013 at AMS13 and at the Wood Buffalo Environmental Association (WBEA) Buffalo Viewpoint monitoring station (AMS4) show low levels for all three types of mercury measured relative to levels typically found in urban areas.

Polycyclic aromatic hydrocarbons (PAHs) and VOCs such as benzene, toluene, ethylbenzene, xylenes, n-butane, n-octane, formaldehyde and methanol were monitored through the air quality monitoring network, including the Fort McKay air monitoring site (AMS1). Measured concentrations of ammonia, methane and non-methane hydrocarbon concentrations at the AMS1 site were consistent with measurements made using other instruments. Results showed a decline in concentrations for all measured chemicals with increasing distance from the oil sands development sites. Sulphur and nitrogen air concentrations and deposition were at very low (background) levels approximately 40–50 km away from the main sources of oil sands emissions.

Did You Know?

While on the ground monitoring of air quality is limited by accessibility and costs, it was augmented and validated in JOSM through satellite observations and sophisticated models that represent the atmospheric chemistry and meteorology over the full region and can be used to predict for future conditions.

3. Water Monitoring

3.1 RIVERS/DELTA

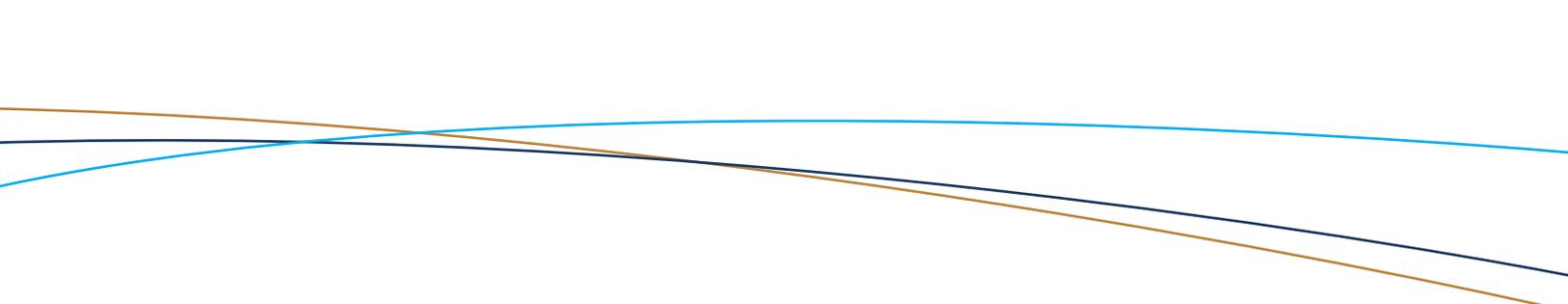
Water quality data collected from 2011 to 2014 by Environment and Climate Change Canada (ECCC) in the lower Athabasca River, and for the 12 sites in and around the Peace-Athabasca Delta were assessed against 36 Canadian Council of Ministers of the Environment (CCME) guidelines. For 19 parameters (alkalinity, pH, 2 nitrogen nutrients, 5 total metals, methylmercury and 9 organic substances), the nearly 900 samples showed no exceedances in any samples.

For the other parameters, exceedances were observed and patterns were similar regardless of geographic location. While some exceedances to interim CCME guidelines for certain PACs (pyrene, benzo[a]anthracene, and benzo[a]pyrene) were noted, the frequency of exceedances was less than 4% of the total number of samples taken. The majority of exceedances were for total metals and occurred only during periods of high flow and high turbidity (e.g., during the high runoff spring and summer seasons). Exceedance rates were highest for total iron, total aluminum and total copper; all other total metals had exceedance rates of less than 20%. These total metal exceedances in the Athabasca, Peace and Slave rivers are within the range of annual variation during high flow periods.

In 2014–2015, data collected by the AEP/AEMERA indicate that exceedances to the Alberta Surface Water Quality Guidelines were recorded at some oil sands monitoring locations including Clearwater River, Ells River, Firebag River, Jackpine Creek, Mackay River, Muskeg River, Steepbank River and Wapasu Creek for cadmium, iron, lead, mercury, silver, zinc and sulphide. In general, with the exception of iron, which did not exhibit any seasonal pattern and silver where a single exceedance was observed during low flow conditions, these exceedances were observed during seasonal high flows (late spring and early summer). Similarly, samples collected from lower Athabasca tributaries by ECCC for the period 2012–2014 showed occasional exceedance of CCME guidelines (e.g., <5% of all samples for total cadmium, total chromium, total silver, total zinc, total arsenic, total selenium) while other parameters frequently exceeded CCME guidelines (i.e., >10% of samples exceeded guidelines for total aluminum, total copper, total iron). The majority of these exceedances also occurred during the snowmelt period when high flows and melting snow result in runoff and erosion into water courses.

Did You Know?

The Athabasca River basin annually experiences a significant period of increased runoff during the spring arising from snow and ice melt (called a “freshet”). This increase in water flows introduces a substantial amount of surface water and sediment into the river system, and typically monitoring data shows exceedances to guidelines for some water quality parameters such as metals.



Intensive water quality monitoring by ECCC during the snowmelt period on several tributaries was undertaken to better understand the seasonal discharge patterns and water chemistry observed. Concentrations of dissolved arsenic, dissolved selenium and total vanadium in the Ells, Muskeg and Steepbank rivers showed similar patterns, with concentrations strongly tracking river discharge. Concentrations were typically greatest during snowmelt (e.g., April to May), peaking at values of 1.31 µg/L for dissolved arsenic, 0.43 µg/L for dissolved selenium and 60.3 µg/L for total vanadium (Ells River during snowmelt 2013) and then declining to lowest values during late fall and winter.

A comparison of the water quality monitoring data at the Old Fort Monitoring Station with indicator triggers and limits as set out in the LARP Surface Water Quality Management Framework showed that no limits were exceeded in 2014. However, Level 2 annual mean triggers were exceeded for sulphate and potassium, and Level 2 peak triggers were exceeded for cobalt and dissolved uranium. Level 2 triggers indicate a shift in ambient water quality conditions from mean and/or peak historical values, and do not necessarily signal additional environmental risk. Confirming whether an undesirable trend is developing and evaluating the consequences of that trend precedes further action when a Level 2 trigger is exceeded.

During fall 2014, water quality at most stations in the larger watersheds (i.e., Athabasca, Muskeg, Ells, Firebag and Clearwater) was consistent with historical and regional observations in the Athabasca oil sands region. However, water quality in the fall in several smaller watersheds differed from regional historical conditions for the lower Steepbank River, lower Hangingstone River, lower Gregoire River, Poplar Creek, lower Beaver River, McLean Creek, Fort Creek, lower Calumet River, Mills Creek, Isadore's Lake and Shipyard Lake.

In fall 2014, sediment quality at all stations sampled was generally consistent with historical observations, and showed negligible differences from regional reference conditions. A decrease in concentrations of total PAHs was observed in sediments at stations of the Christina River, Kears Lake and middle Muskeg River, while an increase in PAH concentrations was observed at Shipyard Lake. With the exception of the lower Christina River, where a trend of decreasing concentrations was observed, none of the sampled sites showed a significant temporal trend in PAH concentrations (normalized to percent-Total Organic Carbon). Bulk suspended sediment collected by ECCC for metals and PAHs via centrifugation demonstrates some variation in the data parameters, both in time and with distance along the Athabasca River, which is not unusual for a dynamic mobile bed river such as the Athabasca River.

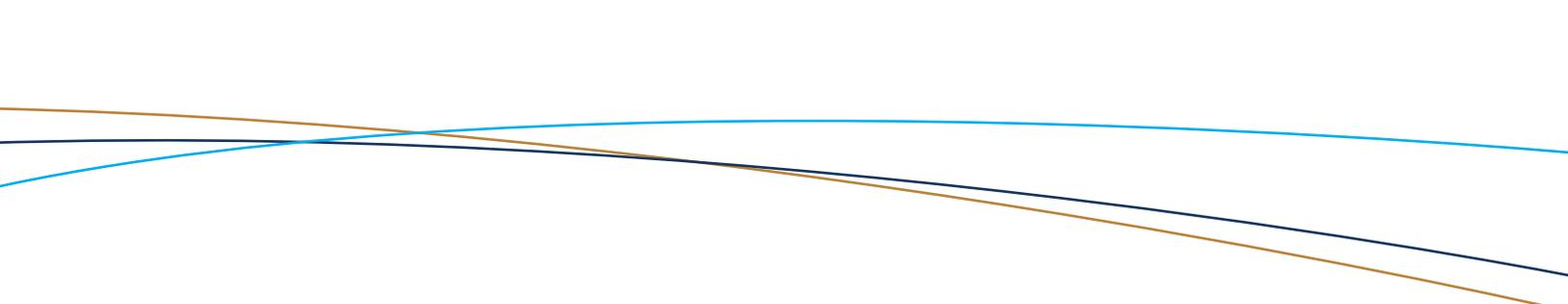
3.2 LAKES/WETLANDS

In 2014–2015, sampling occurred at 45 lakes/wetlands to assess the extent of acidification in the region. Concentrations of key chemical variables monitored in 2014 remained consistent with historical levels. Within the 2014 to 2015 sampling, pH, alkalinity, potassium, magnesium, colour and bicarbonate increased significantly over time, and often in both baseline and test lakes. However, decreases rather than increases in pH and alkalinity are expected during acidification. There were no significant changes in sulphates, while nitrates appeared to be decreasing over time. Nitrates and sulphates are the principal acidifying species from NO_x and SO_x emissions related to oil sands operations. There was no significant increase in aluminum or decrease in dissolved organic carbon. The total base cations increased significantly, but only in the baseline lakes. Taken together, these observations suggest that these lakes are not currently acidifying. Observed changes in ions such as potassium and magnesium were most likely related to hydrologic changes over time involving a possible increase in the role of surficial groundwater in determining lake chemistry.

Did You Know?

Acidification of water bodies can occur because of the atmospheric deposition of SO_x and NO_x , and is particularly a concern should the natural chemistry of the lakes/wetlands and surrounding soils lack the capacity to neutralize the amount of acidifying material being added.

In 2014, concentrations of chemical variables monitored remained similar to historical levels. Results from the analysis of the lakes in 2014 compared with the historical data indicate that there are no significant changes in the water chemistry of the 45 lakes that could be attributed directly to acidification. All sub-regions show negligible indication of incipient acidification.



3.3 SHALLOW GROUNDWATER

Physical and chemical water quality parameters for shallow groundwater for sites near to oil sands tailings ponds compared with shallow groundwater remote from oil sands tailings ponds were statistically indistinguishable for nearly all measured parameters.

3.4 WATER QUANTITY

There was no discernible trend in the percent change in all hydrologic measurement indicators from 2013 to 2014. Negligible changes ($\pm 5\%$) in mean open-water season discharge, mean winter discharge, annual maximum daily discharge and open-water season minimum daily discharge were observed in 8 of the 13 watersheds assessed in the Athabasca oil sands region in 2014–2015. Exceptions were observed for the Muskeg River, Tar River, Mills Creek, Poplar Creek and Fort Creek watersheds, where at least 1 of the 4 stream flow indicators is described as a Moderate ($< \pm 15\%$) or High ($> \pm 15\%$) difference from baseline conditions. These changes may be attributed to activities related to oil sands development including industrial water withdrawals, releases and diversions; landscape management that resulted in a loss of flow to natural watercourses that would have otherwise occurred; and cleared land contributing to increased flows to natural watercourses.

4. Biodiversity And Ecosystem Health Monitoring

Concentrations of oil-sands-related substances have been detected in fish and wildlife living in the oil sands region but not at levels that are showing notable effects on population health or the composition of the biological communities. By contrast, distribution and abundance of many species have been affected by disturbance or loss of habitat.

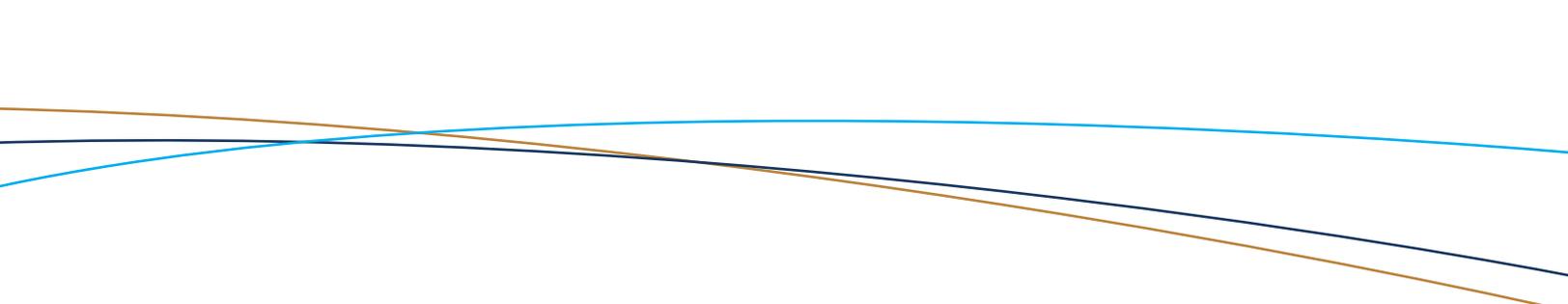
4.1 AQUATIC INVERTEBRATES

Benthic invertebrate communities were diverse, and consisted primarily of Mayflies (*Ephemeroptera*), Stoneflies (*Plecoptera*) and Caddisflies (*Trichoptera*) (EPT) taxa as well as Dipteran (*Chironomidae*) in samples collected from over 50 reference sites in the Athabasca watershed between 2011 and 2014. Benthic community differences were most often linked to differences in substrate, flow and algal primary production. For potentially impacted areas examined in the downstream areas of the Steepbank and Ells rivers, multivariate analyses revealed that invertebrate communities shifted further away from reference conditions (most often defined as reaches of a river upstream and away from the influence of oil sands development) as the proportion of disturbed area in the watershed increased.

Benthic invertebrate community composition varied across channels of the Athabasca River Delta. Negligible differences in the benthic community indicators (species abundance, species richness, i.e., number of taxa, and abundance of EPT) were found in Big Point Channel and the Embarras River. EPT taxa were the major component of benthic macroinvertebrate communities of the Athabasca River mainstem. While this suggests the river is in good ecological condition, increases in pollution-tolerant taxa at some of the river reaches between the Clearwater-Athabasca rivers confluence and approximately 30 km upstream of the Firebag-Athabasca rivers confluences (sites M3 to M7C) suggests early warning signals of environmental stress (e.g., mild nutrient enrichment). Statistically significant differences in benthic community indicators were found for Fletcher Channel and Goose Island Channel. Data collected from Fletcher Channel is indicative

Did You Know?

The composition of benthic invertebrate communities that live on the bottom of river, stream, lake and wetland ecosystems are used as biological indicators of aquatic ecosystem health. In rivers and streams, the relative abundance of Mayflies (*Ephemeroptera*), Stoneflies (*Plecoptera*) and Caddisflies (*Trichoptera*) (EPT), which are considered to be sensitive to pollution, provides insights into local and regional water quality conditions.



of a stable community species composition, including higher species richness and the presence of EPT taxa. The total number of benthic organisms was low in Goose Island Channel, while the relative abundance of tubificid worms was high (potentially reflecting high silt content in the sediments). The percentage of the fauna as EPT taxa was higher in Goose Island Channel in 2014 than previously observed between 2002 and 2013.

The benthic invertebrate communities at all test lakes (i.e., Kearl, McClelland, Isadore's, Shipyard, Gregoire and Christina lakes) were not significantly different from those observed for the reference lakes (Gardiner Lake, Namur Lake and Johnson Lake).

4.2 FISH

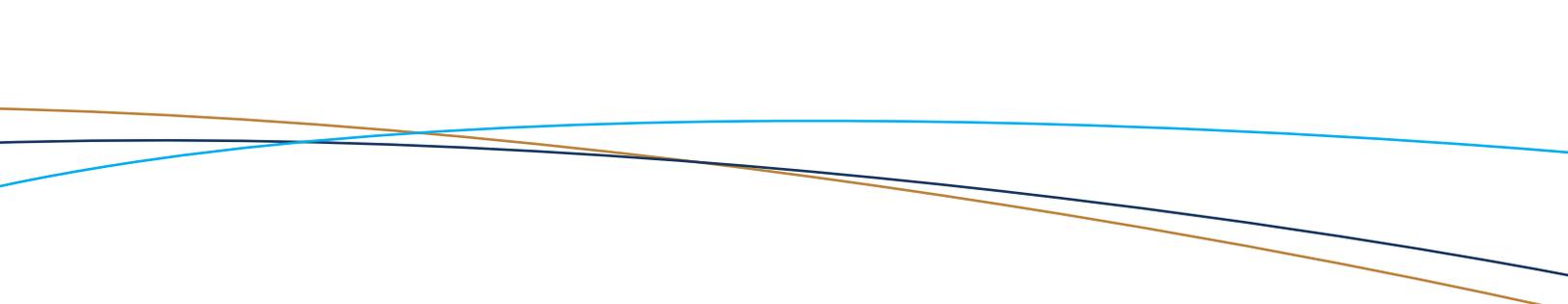
4.2.1 Athabasca River Fish Inventory

Total catch of fish in summer and fall 2014 was much lower compared to 2013, whereas the spring catch in 2013 was similar to that of 2014. The low numbers in the fall total catch were attributed largely to the timing of sampling with respect to the migration of Lake Whitefish from Lake Athabasca to spawning grounds in the Athabasca River upstream of Fort McMurray. New restrictions in the 2014 Alberta Fish Research License meant sampling could not take place during the spawning period (September to January) as in previous years. Lower water levels were also observed in fall 2014, limiting habitat availability for fish as well as boat access and fishing efficiency, contributing to the reduction in total catch and species richness observed in 2014.

There was a decrease in the spring Catch Per Unit Effort of White Sucker in 2014 compared with 2013; it was highest in the Muskeg River, a river used for spawning.

The dominant age class for Northern Pike in 2013 and 2014 was one and two years old, perhaps reflective of continued fishing pressure on older adult fish in the Athabasca River (the dominant age class was five years old from 1997 to 2012). Further focused work is required to assess the specific mechanisms that may be occurring.

Overall, the 2014 fish health assessment for external morphological abnormalities observed among all species were within the historical range (1987 to 2013) despite the higher-than-average incidence of abnormalities observed in Northern Pike (14.8%), which was primarily related to fin erosion. These findings were consistent with previously cited studies published prior to major oil sands development in the upper Athabasca River, the Athabasca River Delta and the Peace/Slave rivers.



4.2.2 Clearwater River Fish Inventory

As the Clearwater River is relatively unaffected by oil sands industrial development, it can provide reference information on the variability and characteristics of natural systems within the region.

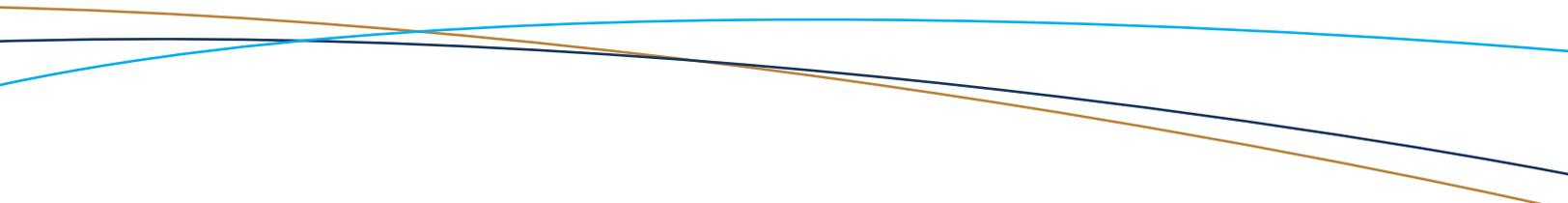
Total fish catches in reaches of the Clearwater River in 2014 were substantially lower compared with 2013. Between 2013 and 2014, total catch decreased by approximately 80% in spring (548 fish in 2013 compared with 108 fish in 2014), and 63% in summer (667 fish in 2013 compared with 247 fish in 2014). A total of 71 fish were also caught in fall 2014; however, fall comparisons were not conducted because the reference reaches could not be sampled due to low water levels.

The dominant age class for Northern Pike has been two and three years since 2012, which represents a shift towards a younger age class, perhaps reflective of continued fishing pressure on older adult fish in the Clearwater River.

In addition, of the 436 fish captured in the Clearwater River in 2014, 87 (20%) had some form of external abnormality such as growths/lesions, parasites, or body deformities. Overall, the incidences of growths/lesions in 2014 increased from 2013 (16.8%); this was primarily related to an observed increase in external parasites. This observation may be related to high water temperature in the Clearwater River in 2014 or other causal factors such as changes in susceptibility to parasitic infection.

4.2.3 Fish Tissue Monitoring

Tissue samples from Athabasca River fish were analyzed for concentrations of metals and other chemical compounds. In 2014, the mean concentration of mercury in Lake Whitefish (milligrams of mercury per kilogram of fish) was higher compared with 2011 but within the range of concentrations observed in previous sampling years. The mean mercury concentration across all size classes of Lake Whitefish were below the Health Canada guideline for subsistence fishers. The mean concentration of mercury in Walleye was also higher in 2014 compared with previous years. The mean mercury concentration in size classes of Walleye greater than 300 mm exceeded the subsistence fisher's guideline for consumptive use. Fish consumption guidelines are currently in effect for multiple species, including specific information pertaining to the Athabasca watershed.



4.2.4 Fish Assemblage Monitoring

In 2014, fish community monitoring was conducted on major tributaries in the oil sands region and channels of the Athabasca River Delta. The objective of this monitoring component was to evaluate fish assemblages, i.e., the number of fish species and their relative abundance. This monitoring was done near the locations where water quality, benthic invertebrate communities and sediment quality were also assessed.

Results of the 2014 fish assemblage monitoring in the Athabasca River Delta indicated a decrease in total fish abundance across all reaches. Lower water levels coupled with higher water temperatures in 2014 (20.4°C to 23.4°C, mean of 22.1°C) compared with 2013 (19.5°C to 20.4°C, a mean of 19.8°C) may have resulted in fish being in deeper, cooler waters, where boat electrofishing was not as effective.

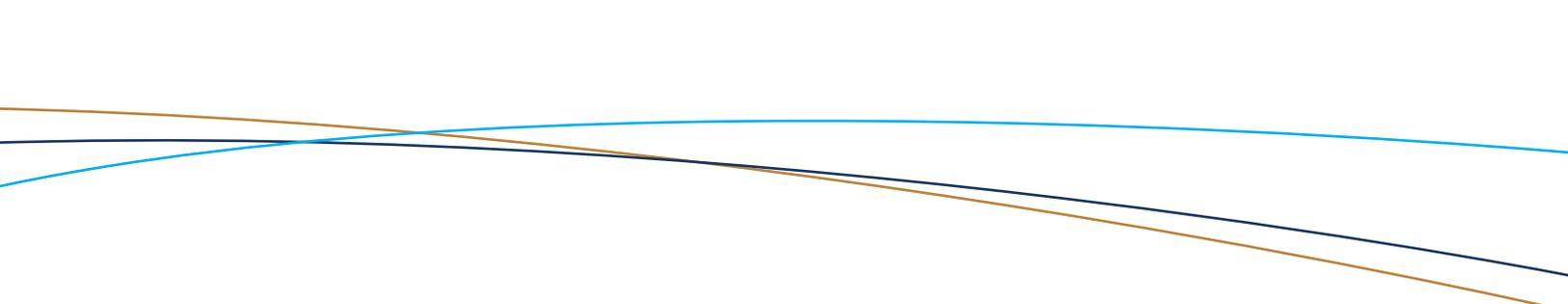
Differences in fish abundance, species richness, diversity and the assemblage tolerance index were not significant at locations most likely to be affected by development compared with regional (“undisturbed”) reference conditions for the Tar River, Christina River above Jackfish River, Sunday Creek, Jackfish River, middle MacKay River, middle and upper Muskeg River, and Poplar Creek. In contrast, significant differences in fish assemblage indicators were observed for the lower Muskeg River, Ells River, Fort Creek, lower MacKay River, Jackpine Creek, Steepbank River, Sawbones Creek and Unnamed Creek east of Christina Lake, where at least three of the four measurements were outside the range of natural variation for three consecutive years.

Differences in fish assemblages observed in 2014 were generally similar to 2013 at sites where measurement endpoints showed variability from reference conditions.

4.3 ECOTOXICOLOGY

4.3.1 Aquatic Organisms

In 2010 and from 2012 to 2014, mussels and freshwater shrimp placed in cages in various tributaries of the Athabasca River displayed no differences in survival or growth at any of the sites between rivers, or when compared with undisturbed reference sites upstream of oil sands mining activities. In addition, no significant biological effects were observed on survival or growth of fish when exposed to natural river conditions. However, biological effects were observed in fish exposed to pure snowmelt in laboratory conditions, indicating that the snowpack contains toxic substances accumulated from atmospheric deposition.



Fathead minnows hatched in the laboratory and exposed to river bed sediment taken from sites near the confluence of the Steepbank and Athabasca rivers showed some abnormalities in early stage growth, but grew normally when placed in water without sediments. However, as a group, these fish produced fewer eggs as adults compared with fish not exposed to these sediments.

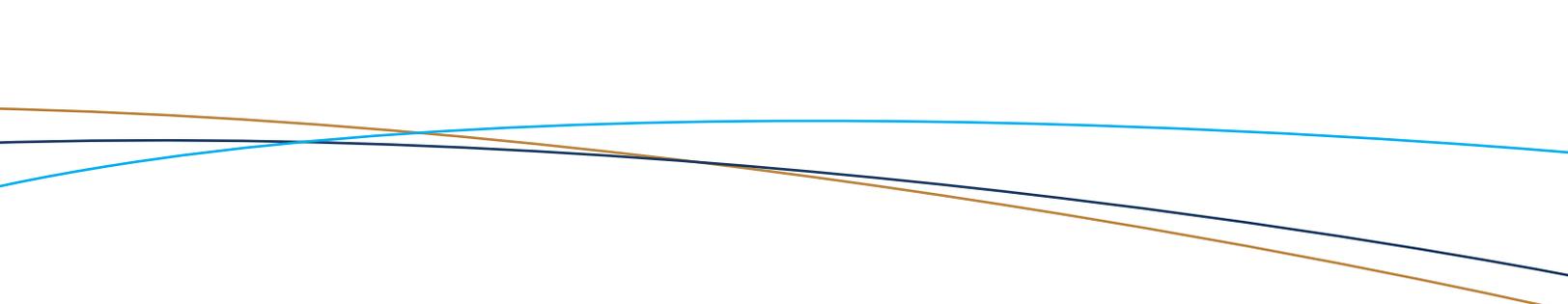
4.3.2 Birds

California Gull eggs from Egg Island show that while mercury concentrations in gull and tern eggs vary annually, there is no evidence that egg mercury concentrations have increased between 2008 and 2013. Current concentrations in a small subset of eggs are approaching the level where the bird health effects may be observed. Current mercury concentrations are also higher than was observed in California Gull eggs collected from the same location in 1977. Other heavy metals, polychlorinated dibenzodioxins and polychlorinated dibenzofurans in these eggs do not reveal any patterns with geographical location or over time.

Studies show that fourteen-day-old tree swallows nesting near oil sands development sites had smaller liver sizes when compared with swallows nesting at sites remote from oil sands development. However, no differences in health and reproductive performance were observed for adult swallows nesting near development sites or at remote locations.

Contaminants were found in the liver tissues of adult males of Fishers, American Marten and Lynx collected in 2013, although there were no obvious spatial patterns between the concentrations of contaminants and the areas where mammal carcasses were collected. Of the liver samples from adult male mallard ducks collected in 2013 from seven areas (Mayerthorpe, Barrhead, Lac La Biche, St. Paul, Vermilion, Fort Chipewyan, Alta.; and Fort Resolution, N.W.T.), only cadmium displayed a spatial pattern, with southern sites (>200 km south of Fort McMurray) showing higher concentrations than sites closer to the oil sands region.

While no applicable wildlife health guidelines exist at present, the expert assessment is that the observed concentrations of these contaminants are not likely currently posing significant ecological risk to these bird or mammal populations.



4.4 TERRESTRIAL BIODIVERSITY

Human footprint, referring to the visible conversion of native ecosystems to temporary or permanent residential, recreational, agricultural or industrial landscapes, is an environmental factor affecting the distribution and abundance of terrestrial species. The overall habitat disturbance caused by human activities (or human footprint) throughout the oil sands region was determined to be 13.8%, distributed as follows: Peace deposit area, 19.6%; Athabasca deposit area, 6.8%; and Cold Lake deposit area, 39%. Agriculture (8.5%) represents the largest single contributor to human footprint over the whole region studied, with the footprint from energy development averaging approximately 2.2%. In the mineable sub-area of the Athabasca deposit, the human footprint from oil sands development is 21% and is associated with both increases and decreases in abundance of some mammals and birds in the oil sands region. Species with observed increases in abundance include Coyote, White-tailed Deer, Black-billed Magpie and Vesper Sparrow, while those with the strongest observed decreases include the Marten, Fisher, Black-throated Green Warbler and Brown Creeper.

Modelling of species occurrence for 67 boreal songbirds suggest that most occupy common habitats and exhibit generalist strategies that would be typical of species in frequently changing habitats. Results from cumulative effects modelling for 30 species of boreal landbirds suggest that the most significant stressors are forestry harvest, well site construction, vegetated linear features (2D and 3D seismic lines, pipelines, powerlines) and roads. Effects of multiple stressor effects are not simply additive but interact synergistically with diverse impacts on boreal landbirds (positive, negative, neutral responses).

Preliminary results of a focused study of nine 25-hectare sites across a gradient of disturbance in steam-assisted gravity drainage development areas revealed that total bird abundance and Palm Warbler (a specialist lowland boreal species) abundance, as well as home range size, was negatively influenced by multiple landscape disturbances. Results from updated habitat-disturbance models for 81 species suggest that species exhibit different levels of sensitivity to oil sands activity. While species like the American Robin, Alder Flycatcher and Song Sparrow showed few differences in density between the oil sands areas and other regions, species like the Black-throated Green Warbler, Ovenbird, Brown Creeper and Canada Warbler had lower densities in areas of industrial activity and overall across the oil sands areas when compared with densities predicted in the absence of human footprint.

4.4.1 Wildlife – Ungulates

Field surveys of deer and moose populations were conducted in 2014–2015 within Alberta Wildlife Management Units (WMUs) where oil sands development is occurring, using both conventional distance sampling methods and a new technology for detecting the thermal radiation signatures of ungulates. Surveys were conducted in 2014–2015 in WMU 527 in the western Peace oil sands area, WMU 519 in the central Athabasca oil sands area, and WMU 503 in the southern Athabasca oil sands area. Results indicate significant regional variability in estimated densities and abundances of moose and deer.

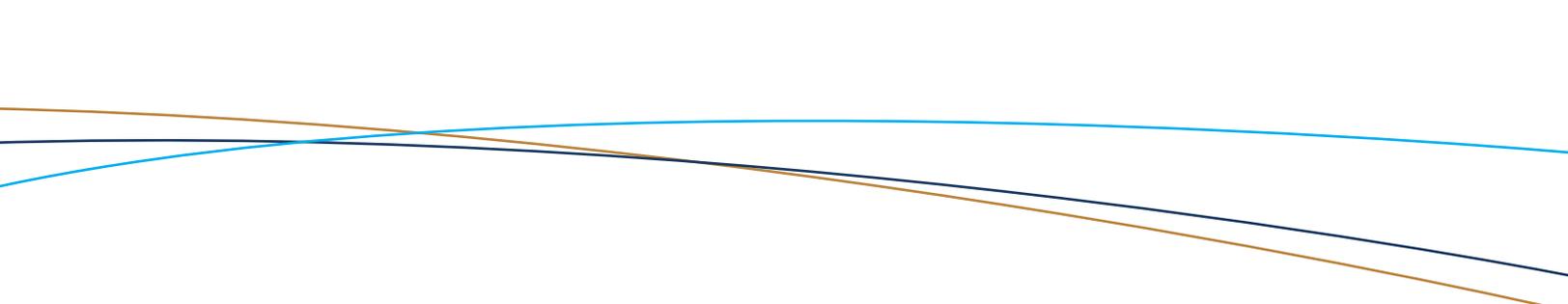
Conventional methods used in WMU 503 estimated that the average density of moose was 0.30 moose/km² and a population size of 946. White-tailed Deer has an estimated average density of 1.62 deer/km² and population size of 5220 deer. In contrast, the new infrared technology produced estimates for moose density of 0.11 moose/km², with a population size of 348.

In WMU 519, just south of the mineable oil sands in the Athabasca oil sands area, the estimated density of moose was 0.135 moose/km² with a population size of 1016.

In WMU 527, in the western Peace oil sands area, estimated average density of moose was 0.284 moose/km² with a population size of 1922. White-Tailed Deer had an estimated average density of 0.234 deer/km² and an average population size of 1584.

Testing indicates that the new infrared technology does not yet provide accurate estimates for moose and deer in the boreal mixed wood forests. Density estimates for moose were nearly an order of magnitude lower than the estimate derived from using the conventional observer-based distance survey method.

Surveys to estimate boreal woodland caribou population size and structure using DNA from fecal pellets were carried out in the caribou range on the west side of the Athabasca River in 2014–2015. Preliminary DNA analysis of caribou fecal pellets from the east side of the Athabasca River indicates that over 90% of the samples collected were successfully profiled. The number of unique genotypes observed in each capture session ranged from 166 to 187 from a total of 1254 samples. Capture–Mark–Recapture analyses are ongoing to provide a population estimate for the caribou range on the east side of the Athabasca River.



5. Summary

Year three (2014–2015) is the final year of JOSM; the governments of Alberta and Canada have provided leadership over the past three years (2012–2015) to design and implement improvements to phased and adaptive ambient environmental monitoring for the oil sands region. An adaptive approach was taken to ensure that governments are responsive to new information and knowledge, and input from key stakeholders. The phased approach was aimed at improving the scientific integrity, accessibility and transparency of results from the multiple ambient environmental monitoring activities conducted by several different organizations.

JOSM has resulted in a more integrated and comprehensive suite of ambient environmental monitoring of air, water, biodiversity, land disturbance, and wildlife contaminants and toxicology, where more data has been generated for a greater range of environmental stressors, sampled at a higher frequency and over a broader geographic area. Focusing mostly on open pit mining areas and regional upgrading operations as the area of largest expected effects, JOSM improved characterization of the state of the environment, and generated information to enhance understanding of the cumulative environmental effects of development activities.

While year three (2014–2015) is the final year of the JOSM implementation plan, more remains to be done in order to solidify the base of evidence on current conditions and long-term trends.

The 2014–2015 findings show that there is consistent, ongoing evidence of low-level changes on the ambient environment related to oil sands development activities that warrant ongoing tracking and more focused studies. Observed changes are most pronounced in the areas in close proximity to intense oil sands development and diminish with increasing distance from current major emission sources or areas of high environmental physical disturbance. Increasing growth of the environmental footprint of the oil sands industry will likely require appropriate consideration and possible expansion of monitoring efforts. The detailed data underlying the information and results in this report can be found on the [JOSM](#) and [AEMERA](#) portals.

As part of JOSM, the two governments committed to have an external, scientific peer review of the scientific integrity, design and implementation of JOSM. The objective of the review was to assess whether JOSM improved the scientific integrity of environmental monitoring in the oil sands region relative to monitoring that existed prior to the implementation of JOSM in 2012, and to make recommendations on how to maintain and/or further improve the scientific rigour and transparency of monitoring in the oil sands region. The goal continues to be making valid and comprehensive data available to support sound decision-making for environmentally responsible oil sands development. The final recommendations of the science integrity review are expected in spring 2016.

6. Abbreviations

ORGANIZATIONS

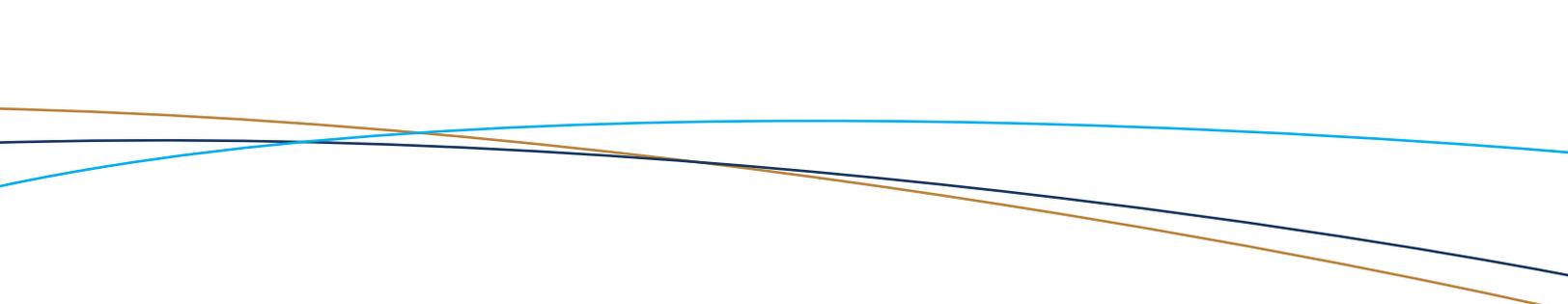
ABMI	Alberta Biodiversity Monitoring Institute
AEMERA	Alberta Environmental Monitoring, Evaluation and Reporting Agency
AEP	Alberta Environment and Parks
AER	Alberta Energy Regulator
CCME	Canadian Council of Ministers of the Environment
ECCC	Environment and Climate Change Canada
LICA	Lakeland Industry and Community Association
WBEA	Wood Buffalo Environmental Association

ACRONYMS

AAAQO	Alberta Ambient Air Quality Objective
EPT	<i>Ephemoptera</i> (Mayflies), <i>Plectoptera</i> (Stoneflies) and <i>Trichoptera</i> (Caddisflies)
LARP	Lower Athabasca Regional Plan
SAGD	Steam-Assisted Gravity Drainage
WMU	Wildlife Management Unit

CHEMICAL SUBSTANCES

DNA	Deoxyribonucleic acid
NA	Naphthenic acid
NO ₂	Nitrogen dioxide
NOX	Oxides of nitrogen
PAC	Polycyclic aromatic compound
PAH	Polycyclic aromatic hydrocarbon
SO ₂	Sulphur dioxide
SO _x	Oxides of sulphur
VOC	Volatile organic compound



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